bestowed a great deal of care and trouble, trusting only to averages of many repeated measures, did not agree satisfactorily with the maker's statement. I do not know whether it may have been generally noticed, but the remark is a very obvious one, that the limit of numerical error increases with the power, so that in the case at any rate of ordinary dynameters, minute accuracy in the estimates of very deep oculars bears evidence of its own futility. If it represents anything of value, it can only be the care and attention with which a mean was deduced from repeated trials; but even this would be better expressed in round numbers, as less likely to convey an erroneous impression to the uninitiated.

Probably some form of apparatus may yet be devised which may secure greater minuteness in the measurement of very high powers, without entailing a disproportionate outlay. In the mean time Mr. Berthon's invention may be safely recommended as likely to prove of especial advantage to observers in general.

T. W. WEBB

THE NEW GANOID FISH (CERATODUS) RECENTLY DISCOVERED IN QUEENSLAND

II.

It appears to me that there is not the least justification for separating the living fish *generically* from that extinct form, the teeth of which are known by the name of *Ceratodus*. Immediately after its discovery became known, and before we knew more than the outlines of its external characters, views to the contrary were expressed, evidently based on the assumption that a genus was not likely to have survived from the Triassic epoch. This is certainly a remarkable fact, but it is not more surprising than the other, viz., that fishes from one of the oldest epochs from which fish remains are known, are most closely allied to *Ceratodus*. We know that the same *species* occur on both sides of the Central-American isthmus—that is, that they have existed at, and remained unchanged from, the time when the Pacific and Atlantic Oceans were connected by one or several channels. Therefore, it would appear that there is a greater persistence in the ichthyic type than we have hitherto been willing to admit.

Whoever has compared the teeth of *Ceratodus runcinatus* from the German Muschel-Kalk, and those of the Indian species described by Prof. Oldham, with the teeth of the living species, must admit their generic identity; and if the Australian form really grows to the enormous size stated by some colonists, I have no doubt that the teeth of such large examples cannot be distinguished from the fossils mentioned. So close a resemblance in highly specialised teeth like those of *Ceratodus* is generally admitted to be of generic significance. Unfortunately no other part of *Ceratodus* is known to have been preserved in the fossil state to serve as a further guide in answering this question. The strata in which the teeth are found must have been much disturbed, as no two teeth have ever been met with *in situ* together; but I cannot help thinking that sooner or later the vomerine teeth will be recognised. From their smaller size they would easily have escaped observation; and their shape (which differs so much from that of the molars) would scarcely have allowed an observer to connect them with the genus to which they in reality belong.

The next most nearly allied forms are the American and African *Lepidosirens*, a genus at present unknown in a fossil state. The skeleton (in some respects even to its minute details), structure of the fins, dentition, internal nostrils, three-chambered heart, co-existence of a lung with gills, intestinal tract, small size of ova: all present the strongest possible evidence of the close relationship between these fishes. The points in which they differ are of such a nature that characters indicative of an amphibian affinity in *Lepidosiren* are modified in *Ceratodus* according to a distinctly ichthyic type, thus tying, as it were, *Lepidosiren* firmly to the class of fishes. The longitudinal valves in the bulbus arteriosus of *Lepidosiren*, reminding us of a similar structure in the heart of Batrachians, are replaced by truly Ganoid valves in *Ceratodus*; the imperfect gills of the former genus are as perfect in the latter as in any other fish; the lungs of *Lepidosiren*, paired as in a frog, are confluent into a single air-bladder-like sac in the Australian form; instead of the closed ovaries with a developed oviduct and fallopian tubes of *Lepidosiren*, we find the ovaries of the Barramunda open, discharging the ova into the abdominal cavity, as in the Salmon family and other fishes. These differential characters may be considered by some of sufficient importance to refer the *Lepidosirens* and the Barramunda to two distinct groups.

Some of the oldest fishes, known from the Devonian epoch, are designated by the names *Ctenodus* and *Dipterus*. Whether they should be referred to one genus or two is a question about which opinions are divided, and into which I need not enter here. They are evidently representatives of the same ichthyic type as the Dipnoi of the present epoch. The similarity of the large molars to those of *Ceratodus* has been recognised for a long time; but it is only recently that I have been able to ascertain, in an example in the Jermyn Street Museum, the presence of a pair of small vomerine teeth. Moreover, the same example presents as good evidence as we can expect in a fossil, that the nostrils are placed within the mouth. These characters are combined with the presence of acutely lobed paddles, and of a notochordal skeleton; but there is the great difference that the end of the vertebral column is heterocercal, instead of being diphyocercal, as in *Lepidosiren* and *Ceratodus*. Therefore *Ctenodus* will form the type of a distinct dipnöous family.

Thus, then, we arrive at the conclusion that *Lepidosiren*, far from being an isolated representative of a distinct subclass of fishes, is only one of the representatives of a sub-order of Ganoid fishes, characterised by the position of the nostrils within the mouth, by paddles supported by a jointed axis, by lungs co-existent with gills, by a notochordal skeleton, and by the absence of branchiostegals. The term "Dipnoi" may be retained for this sub-order, which was developed in the earliest epochs from which fish-remains are known, while we have scanty evidence of its presence in Liassic and Triassic strata, and, in the present state of our knowledge, it appears to be lost, until we find it again represented by three living forms in the present period. Probably some other extinct genera belonged also to this sub-order, but their remains are in too fragmentary a condition to admit of an exact definition of their affinities.

During the examination of *Ceratodus*, I had so frequently occasion to refer to structural peculiarities of the *Plagiostomata* (Sharks and Rays), that I was induced to reconsider the relations existing between this sub-class and the Ganoid and Teleosteous fishes; and I came to the conclusion that the two former are much more nearly allied to each other than the Ganoids are to the Teleostei. The Plagiostomes were considered to be a distinct sub-class of fishes on account of the highly-developed state of the organs of reproduction in the female, besides the presence of copulatory organs in the male. Their ova are different from those of other fishes, having a very peculiar shape, and shell with adhesive appendages, and being of an unusually large size, and few in number. They are impregnated internally; some of the species are viviparous. They have from five to seven external gill-openings. Although in external appearance a Ray and a Shark are apparently very different, yet these extremes are connected by a number of intermediate forms, and they form altogether one of the most homogeneous groups in the zoological system.

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On the other hand they agree with the Ganoids in having, in addition to the ordinary two divisions of the fish-heart, a third contractile chamber. This bulbus arteriosus is very different from the *Bulbus aortæ* of the Teleosteous fishes, where it is simply a swelling of the walls of the aorta, not contractile, without valves in the interior, and separated from the heart by two valves opposite to each other. If this remarkable arrangement is deemed (and, I think, very justly) to be sufficient to separate the living Ganoids as a sub-class from the *Teleostei*, it is certainly significant enough to suggest the union of the Ganoids with the Plagiostomes. Moreover, this character is supported by two others of great importance, viz., the presence of a spiral valve in the intestine, which is found in a more or less developed state in all Ganoids, Sharks, and Rays, but is entirely absent, even in a rudimentary condition, in the Teleostei, and by the optic nerves being placed side by side, and not decussating, as is the case in all our ordinary fishes. Of the characters connecting these fishes I will refer to one other, as it has been described above, namely, that the fore and hind limbs of the Plagiostomes are also paddles supported by a cartilaginous structure, as in the *Dipnoi*.

The evidence in favour of a union of Ganoids with Plagiostomes is rendered complete by the Chimæras, which hold a surprisingly intermediate position. They are Sharks in external appearance and with regard to the structure of their organs of propagation; they are provided with the same copulatory organs, and their ova are large, enclosed in a horny case, and provided with adhesive appendages. Many species of Sharks, when in a very young state, are provided with a double dorsal series of spines (permanent in certain Rays), which are lost with age; and this most remarkable developmental character occurs likewise in young Chimæras. On the other hand, there is only one external gill-opening on each side, as, for instance, in *Ceratodus*, which, on the other hand, shows the first step towards a coalescence of the gills with the walls of the gill-cavity. The skeleton is notochordal, and the palatal and maxillary apparatus coalesce with the skull, as in *Dipnoi*, which is not the case in any Plagiostome; likewise the dentition approaches that of *Ceratodus*. Finally, Sir P. Egerton has drawn attention to the most important fact that the dorsal spine is articulated to a neural apophysis, and not merely implanted in the soft parts and immovable, as in Sharks.

Thus, then, the union of these fishes in one sub-class appears to me fully justified, as far as the living forms are concerned; but, as is implied by the name *Palæichthyes*, which I have proposed for this sub-class, it is intended to comprise also a great variety of forms from the Palæozoic Era, in fact, the predecessors of the Teleostean fish-fauna of the present period. I am aware of the objections that may be urged. First, it may appear to some to be an improper proceeding to unite in the same sub-class fishes of so different an appearance as a Shark and Lepidosiren, or as an Amia and a Pteraspis; but let them consider what a comprehensive category a sub-class necessarily is—that the diversity between the fishes just named is not greater than that existing between a Sun-fish (*Orthagoriscus*) and an eel, or between a viviparous Embiotoca and a Loricaria, forms admitted by every ichthyologist of the present day as members of the same sub-class, that of Teleosteans. In fact the Palæichthyes are composed of a similar series of modifications as the Teleosteans, some of the members of one sub-class exhibiting marked analogies with those of the other, in the same manner as is the case with Placentalia and Implacentalia among mammals. To mix up ganoid-looking Teleosteans, like the Siluroids, with Ganoids, is as little in accordance with the advanced state of our ichthyological knowledge, as the union of Salamandra with Lacerta would be. Secondly, other naturalists may consider it very hazardous to establish a division, of which the majority of members are extinct and known from remains of the hard parts only, and to characterise it by peculiarities of the soft parts. But why should we not make use of zoological evidence for the completion of the imperfect palæontological record, with the same benefit to science as in other cases, since not a few zoological problems have been, or can only be, solved by reasoning founded on palæontological facts? If, in the determination of affinities, we were to limit ourselves only to the consideration of those parts which have been preserved in the process of fossilisation, we could never expect any other result but the creation of most artificial assemblages of forms, although the characters of some natural families, or even orders, might be partly recognised.

On the one hand, we know that all the Teleosteous fishes, that is, the types which are predominant in the present and next preceding epochs, and which were but sparingly (*Coccosteus?*) represented in the Palæozoic, if they existed at all, agree, in spite of all other differences, with one another in possessing a two-chambered heart, with a rigid bulbus aortæ and decussating optic nerves, and in never exhibiting a trace of a spiral valve in the intestine.* On the other hand, we find that the few ichthyic types which have survived from the Palæozoic Era into our period, and those of which no immediate representative is known in that Era, but which approach that Amphibian fish-type by unmistakeable characters, agree, in spite of all other differences, in having a three-chambered heart, non-decussating optic nerves, and a spiral valve in the intestine. These are facts; and it seems to be a fair conclusion that the members of the Palæozoic fish-fauna had essentially the same organisation of those soft parts as their surviving representatives.

In conclusion I may shortly pass in review the living *Palæichthyes*, especially in regard to their distribution over the globe.

1. Of the order *Plagiostomata* or *Marine Palæichthyes*, 140 species of Sharks, distributed among 39 genera, are known, and 150 species of Rays, belonging to 25 genera. They inhabit nearly all the seas of the globe, decreasing in number from the tropics towards the poles. Only very few enter or live in freshwater.

2. The order *Holocephala* contains only four species, viz., three Chimæras and one Callocephalus; they are restricted to the seas of the temperate zones of both hemispheres, and are absent between the tropics.

3. The order *Ganoidei* or *Freshwater Palæichthyes* is represented by one species of *Amia*, from North America; three species of *Lepidosteus*, from the same region, but extending southwards into Central America and Cuba; two species of *Polypterus* (*Calamoichthys*) from the tropical parts of Africa; two species of *Polyodon*, from the Mississippi and the Yantsekiang; about twenty-five Sturgeons, from the temperate and sub-arctic regions of the Northern Hemisphere; two species of *Ceratodus* from tropical Australia; one species of *Lepidosiren* from the Amazon river, and one of *Protopterus* from tropical Africa. Although the majority of the Sturgeons pass a part of the year in the sea, they must be regarded as freshwater fishes like the migratory Salmones, because they deposit their spawn in the rivers, where they also pass the first period of their growth; some species never enter the sea at any period of their life, and none are known to propagate in the sea.

The total number of fishes known at present being about 9,000, the *Palæichthyes* form only 3·6 per cent. of that number. But from the extent of the regions hitherto ichthyologically unexplored, and from the numerous additions annually made to the list of known forms, I do not believe that we are acquainted with much more than one-tenth of the species of fishes actually existing.

ALBERT GÜNTHER

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* From these considerations *Amphioxus* and the *Marsipobranchii* are excluded, the former being evidently the type of a distinct sub-class

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